James River Alternatives Analysis

D R A F T

Addendum #4

VATS JY1 & VATS JY2

James River Waste Load Allocations and York River Model Scenario:

October 6, 2005

Prepared by:
Virginia Department of Environmental Quality
in cooperation with the
U.S. EPA Chesapeake Bay Program Office

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VATS JY1 & VATS JY2
James River Waste Load Allocations and
York River Based Point Source Nutrient Control Regulations

October 6, 2005

Introduction:

Following a series of meetings in August with DEQ staff, two additional model simulations were requested by the Virginia Association of Municipal Wastewater Agencies (VAMWA 2005a,b). This action was the result of adoption (and subsequent suspension) of the Water Quality Management Plan Regulations (9 VAC 25-720) and Water Quality Standards (9 VAC 25-260) by the State Water Control Board (SWCB) in June. Final agreement was reached to conduct additional water quality responses in both James and York Rivers based on revised point source allocations. Results of these model scenarios (VATS JY1 and VATS JY2) are described herein.

Background:

New waste load allocations (WLA) recommended by DEQ staff for inclusion in the Water Quality Management Plan Regulations (9 VAC 25-720) were adopted by the SWCB on June 28, 2005 and subsequently suspended following further analysis. While revised WLAs were developed for the Rappahannock, Virginia's Easter Shore and Potomac Basins and presented to the SWCB on September 27th and subsequently approved, no action was sought for the James and York River Basins pending this investigation. Two additional scenarios, VATS JY1 and VATS JY2, were completed based on consensus developed in August and September (DEQ 2005). The point source concentrations reflected in Table A were designed to investigate chlorophyll *a* responses to the lower estuary of James River and phosphorus limitation in York River. A description of other similar scenarios is provided in Table B.

Table A. Annual average point source nitrogen and phosphorus concentrations by basin and scenarios (modified from the VAMWA 2005b).

Scenario	VATS JY1		VATS JY2	
	TN	TP	TN	TP
James River				
AFL	6.0 mg/L	0.5 mg/L	6.0 mg/L	0.5 mg/L
TF	5.0 mg/L	0.5 mg/L	5.0 mg/L	0.5 mg/L
LE	5.5 mpy	1.0 mg/L	6.9 mpy	1.0 mg/L
York River				
	6.0 mg/L	1.0 mg/L	8.0 mg/L	1.0 mg/L
Other basins	VATS or TS		VATS or TS	

Notes: NPS and sediments at VATS for James and York Rivers; mpy – million pounds per year.
Source: DEQ letter to VAMWA dated September 27, 2005

As noted in the James River Alternatives Analysis (JRAA 2005a,b,c,d), fifteen scenarios have been used to describe anticipated water quality responses to a suite of nutrient loadings. Table 2.1 lists the James River nutrient and sediment loads from the CBP Watershed Model for each of the scenarios including the last two scenarios described above for both James and York River.

Point source delivered loads from each James River basin segment were computed by the CBP Watershed model for each scenario are shown in Table 2.3. The basic assumptions used for nutrient and sediment loadings employed for each of the other simulations can be found in Table 2.4 of earlier reports (JRAA 2005a,b,c,d).

Table B. Virginia Tributary Strategy scenario descriptions from James River Alternatives Analysis (2005a, b, c, d)

VATS	Virginia Tributary Strategy scenario reflects estimated nutrient reductions based on Bay states tributary strategies.
VATS Alternative	Virginia Tributary Strategy Alternative (Alternate) scenario applied controls of enhanced nutrient reductions to point source dischargers to the lower James River (meso- and polyhaline) resulting in lower TN and TP loads than VATS.
VATS JR Initial	Virginia Tributary Strategy James River Initial was based on the same total load allocations of VATS JR Alternative except with above fall line point sources at Virginia Tributary Strategy (VATS) levels. The tidal point sources were at VATS JR Alternate loadings.
VATS JR Alterative	Virginia Tributary Strategy James River Alternative (Alternate) was based on load allocations adopted (and subsequently suspended pending additional public comment) by the SWCB in June of 2005.

A comparison of the delivered point source loads for York River under three nutrient reduction scenarios is provided below (Table C). As noted in Table A, the two new scenarios reflect a three fold increase in total phosphorus to1.0 mg/L under VATS JY1 and VATS JY2 from 0.3 mg/L under VATS.

Table C. York River estimated delivered loads for point sourced nitrogen and phosphorus.

Scenario	TN (million pounds per year)	TP (million pounds per year)
VATS	994, 057	85,198
VATS JY1	1,007,027	233,333
VATS JY2	1,192,555	233,333

Criteria attainment for dissolved oxygen was based on the cumulative frequency distribution (CFD) using the published biological reference curve based on 10 years (USEPA 2003). Green indicates attainment while blue values are less than 1% non-attainment with red greater than 1% non-attainment.

Results of Model Scenarios:

James River Chlorophyll a –

The point source load changes associated with VATS JY1 and VATS JY2 resulted in average spring and summer chlorophyll *a* concentrations similar to other VATS simulations (VATS, VATS Alternate, and VATS JR Alternate). The major difference was higher spring and summer chlorophyll *a* concentrations in the lower tidal fresh (JMSTF1) and oligohaline (JMSOH) (Table 3.1, Tables 6.1a and 6.1b). The upper tidal fresh (JMSTF2) concentrations actually increased above reference levels during the summer estimated from ten-year average spring and summer chlorophyll *a* concentrations. Similar to VATS and VATS Alternate, VATS JR Alternate, VATS JY 1 & 2 indicated attainment of the proposed 25 ug/L Chl-*a* water quality standard for the summer at the lower tidal fresh (JMSTF1) (Table C.4); however, failed the 15 ug/L threshold for the same region during the spring (Table C.3). Non-attainment of the proposed chlorophyll *a* standard was also observed during the summer at JMSOH, and spring at stations JMSMH and JMSPH (Tables C.6, C.7 & C.9, respectively).

The cumulative frequency distribution (CFD)-based attainment of the proposed chlorophyll *a* criteria for the tidal James River segments, for both a ten-year average and a running three-year average, are presented in Tables 3.3 to 3.12 for management scenarios including VATS JY1 and VATS JY2 (replacing Tiers 1, and 2 Scenario shown in earlier documents).

Table 2.1. James River basin model estimated total nitrogen (TN), total phosphorus (TP), and total suspended sediment (TSS) loads for point and non-point sources delivered to tidal waters. Nutrients in million pounds; sediments in million tons.

Scenario	TN	TP	TSS *
1985 Reference	46.9	8.51	1.28
2002 Assessment	37.7	5.80	1.18
Tier 1	37.3	6.20	1.14
Tier 2	28.2	5.04	1.07
Tier 3	23.0	3.91	0.95
VATS	25.4	3.49	0.82
VATS Alternate	23.9	3.37	0.82
VATS JR Initial	26.8	3.59	0.82
VATS JR Alternate	26.8	3.59	0.82
VATS JY1	**26.6**	**3.66**	**0.82**
VATS JY2	**28.0**	**3.66**	**0.82**
Option 4	28.1	3.75	0.97
E3	15.2	2.83	0.79
Scoping Scenario A	37.6	6.31	0.82
Scoping Scenario B	33.8	5.77	0.82
Scoping Scenario C	36.1	6.13	0.82
Scoping Scenario D	22.6	3.90	0.82

* TSS loads were calculated from the watershed sediments but don't include shoreline sediment reductions below the fall line.
Source: U.S. EPA Chesapeake Bay Program Office with correction to VATS JR Alternative as recorded in Addendum #2.

York River Dissolved Oxygen –
Results of dissolved oxygen attainment for York River under various reduction scenarios including the most recent VATS JY 1 & 2 is shown in Table D. The tidal river met the migratory use except segment MPNOH. It failed under all the reduction scenarios beyond Progress 2000. Most of the tidal waters were in attainment for open water. Those that didn't meet their use under Observed showed improvements under nutrient control measures. Most notable was YRKMH that began with over 18% non-attainment, but was less then 1% non-attainment beyond nutrient controls associated with Progress 2000. Two segments of the tidal river were in non-attainment for migratory and open water under E3.

Table 2.3. James River point source total nitrogen (TN) and total phosphorus (TP) loads (million pounds) delivered to the basin segment from the watershed model. (AFL-above fall line; lower estuary – everything below the tidal fresh)

	TN				TP			
SCENARIO	AFL	Tidal Fresh	Lower Estuary	TN Total	AFL	Tidal Fresh	Lower Estuary	TP Total
1985 Reference	1.13	15.0	7.2	23.3	0.55	1.57	1.83	3.95
2002 Assessment	0.86	7.9	6.4	15.1	0.72	0.50	0.53	1.75
Tier 1	2.05	6.8	7.9	16.7	0.77	0.80	0.61	2.18
Tier 2	0.74	5.7	3.9	10.3	0.34	0.64	0.48	1.46
Tier 3	0.80	3.7	2.4	6.9	0.16	0.33	0.24	0.73
VATS	0.78	5.0	5.4	11.2	0.38	0.34	0.46	1.18
VATS Alternate	0.78	5.0	3.9	9.7	0.38	0.34	0.35	1.07
VATS JR Initial	0.78	6.3	5.5	12.6	0.38	0.30	0.60	1.28
VATS JR Alternate	0.83	6.3	5.5	12.6	0.33	0.30	0.60	1.23
VATS JY1	**0.91**	**6.7**	**5.5**	**13.1**	**0.37**	**0.41**	**0.60**	**1.38**
VATS JY2	**0.91**	**6.7**	**6.9**	**14.5**	**0.37**	**0.41**	**0.60**	**1.38**
Option 4	0.70	4.9	3.1	8.7	0.13	0.35	0.24	0.72
E3	0.62	2.6	1.3	4.5	0.04	0.10	0.04	0.18
Scoping A	1.15	6.7	7.7	15.6	0.99	0.57	0.63	2.19
Scoping B	0.76	5.7	6.4	12.8	0.99	0.64	0.53	2.16
Scoping C	2.05	6.8	7.9	16.7	0.77	0.80	0.61	2.18
Scoping D	0.80	3.7	2.4	6.9	0.16	0.33	0.24	0.73

Source: U.S. EPA Chesapeake Bay Program Office with a correction to JRAA Table 2.3 for the AFL VATS and VATS Alternate

Table D York River dissolved oxygen criteria attainment by scenario based on designated use (MIG – migratory; OW – open water) (A refers to attainment; blue less than 1% non-attainment with red greater than 1% non-attainment) using the ten year CFD.

Segment	DU	Observed	Progress 2000	Allocation	Confirmation	VA trib strat	VATS JY1	JVATS Y2	E3
York Lower Piankatank (PIAMH)	OW	0.12	A	A	A	A	A	A	A
York Tidal Fresh Mattaponi (MPNTF)	MIG	A	A	A	A	A	A	A	A
	OW	A	A	A	A	A	A	A	0.02
York Mid- Mattaponi (MPNOH)	MIG	A	A	1.37	2.12	2.62	2.62	2.43	6.06
	OW	2.04	A	A	A	A	A	A	2.20
York Tidal Fresh Pamunkey (PMKTF)	MIG	A	A	A	A	A	A	A	0.10
	OW	A	A	A	A	A	A	A	A
York Mid- Pamunkey (PMKOH)	MIG	A	A	A	A	A	A	A	A
	OW	A	A	A	A	A	A	A	A
York Lower (YRKMH)	MIG	A	A	A	A	A	A	A	A
	OW	18.08	4.85	0.15	0.19	0.04	0.04	0.05	A
York Lower (YRKPH)	OW	1.41	A	A	A	A	A	A	A
	DW	0.01	A	A	A	A	A	A	A
York Lower Mobjack (MOBPH)	OW	2.30	1.78	0.25	0.30	0.18	0.18	0.20	A

Discussion:

It has been demonstrated that the Water Quality Model used to develop chlorophyll *a* and dissolved oxygen responses provides a scientifically sound representation associated with eutrophication in the bay and tidal tributaries (Cerco and Noel 2004). The predictive capability to model chlorophyll *a* and dissolved oxygen successfully computes broad spatial and temporal domains within the estuary.

It is important to remember these model results reflect calculated seasonally averaged chlorophyll-*a* and dissolved oxygen concentrations based on broad spatial and temporal domains (ten years of hydrology by CB segment). However as stated previously, incremental changes to nitrogen and phosphorus loads could have significant influence on local water quality over much shorter temporal and spatial scales (day and station) (JRAA 2005b). Phytoplankton respond hourly to subtle physical, chemical (nutrient) and biological changes in the water column. This includes temperature and light (day vs night, cloudy vs clear) and vertical mixing (flows and wind events) effects on nutrient concentrations (DIN, DIP, and DIN/DIP), not to mention self-shading (from Hydrilla to Microcystis mat formation) or grazing. Such incremental changes are not captured by the model. Therefore, to best control current over production in these tidal waters and reduce the risk of algal blooms, the most comprehensive nutrient controls should be sought.

James River Chlorophyll a –

Based on the results of previous scenarios (JRAA 2005a,b,c,d), chlorophyll *a* responds to location and size of load adjustments. For example, largest load adjustment resulted in the greatest chlorophyll *a* response. Conversely, small load adjustments didn't generate much of a chlorophyll *a* response. Also, tidal fresh James River responded mostly from loadings associated with the above fall line and tidal fresh inputs (Table 3.1).This is not surprising given the broad spatial and temporal domains of the model.

While both VATS JY scenarios displayed chlorophyll *a* improvements beyond 85 Reference conditions, these runs demonstrated that loadings above the fall line and tidal fresh regions triggered significant chlorophyll responses. Lower estuary responses associated with VATS JY1 were close to VATS and VATS JR Alternate while VATS JY2 was comparable to results associated with VATS Alternate. Under both VATS JY1 and VATS JY2, non-attainment of the proposed chlorophyll *a* standards was observed at JMSOH during summer, and both JMSMH and JMSPH during the spring (Tables C.6, 7 & 9, respectively)(Table C.1 through C.10).

York River Dissolved Oxygen –

Based on the scenarios presented above, there was little change in dissolved oxygen conditions in York River between Confirmation, VATS and VATS JY1 & 2. It is inconclusive why two York River segments displayed non-attainment for dissolved oxygen under nutrient reductions. One hypothesis is the balance between algal production and the influence of nearby wetlands. Algae decline under nutrient reductions. Consequently, algal production of dissolved oxygen goes down. The extensive wetlands in the region create an oxygen sink. If overall water column oxygen production goes down with a constant, large sink, then the model calculates an oxygen deficit. The result is low levels of oxygen reflected as non-attainment. The role of benthic algae and model performance under these scenarios has not been explored. While benthic algae have a direct connection to nutrients regenerated by sediments, they potentially could be limited by water column nutrient reductions as well. The large oxygen problem at the

E3 nutrient reduction level suggests that even benthic production is becoming limited. Though the model has limitations in representing wetlands, it's response in this case could be correct.

Emperical studies have shown that light is the limiting resource to algal growth in much of the low salinity York River (Haas and Webb 1998). Based on nutrient ratios, P-limitation is possible in much of the low salinity regions; however, most of the tidal river maintained nutrient concentrations well above algal needs (most of the system was nutrient saturated) (Butt 2005). Nitrogen limitation was evident during the summer in the high salinity regions not nutrient saturated. If light limitation was removed, current conditions would increase the risk of algal blooms since nutrient concentrations far exceed algal needs. The balance between N to P remained relatively unchanged with nutrient reductions based on model simulations; however, the tidal fresh York River remained largely "saturated" with dissolved inorganic nutrients.

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Table 3.3. The CFD based assessment of spring chlorophyll water quality criteria attainment in the James Upper Tidal Fresh (JMSTF2). A = attainment; % = percent of time/space not in attainment.

James Upper Tidal Fresh - Spring				*SCENARIOS*					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier 3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY1*	*VATS JY2*
1985-1987	--	--	--	--	--	--	--	--	--
1986-1988	A	A	A	A	A	A	A	A	A
1987-1989	A	A	A	A	A	A	A	A	A
1988-1990	A	A	A	A	A	A	A	A	A
1989-1991	A	A	A	A	A	A	A	A	A
1990-1992	A	A	A	A	A	A	A	A	A
1991-1993	A	A	A	A	A	A	A	A	A
1992-1994	19.3%	19.3%	19.6%	20.1%	19.6%	19.6%	19.6%	19.6%	19.6%
Avg of 3-Yr Pds	2.8%	2.8%	2.8%	2.9%	2.8%	2.8%	2.8%	2.8%	2.8%
10-Year Avg	3.9%	3.9%	4.0%	4.3%	4.0%	4.0%	4.0%	4.0%	4.0%

Table 3.4. The CFD based assessment of proposed summer chlorophyll water quality criteria attainment in the James Upper Tidal Fresh (JMSTF2). A = attainment; % = percent of time/space not in attainment.

James Upper Tidal Fresh – Summer				*SCENARIOS*					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier 3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY1*	*VATS JY2*
1985-1987	1.7%	16.3%	16.0%	19.2%	17.5%	17.5%	18.1%	18.1%	18.1%
1986-1988	1.7%	22.9%	25.8%	34.5%	24.3%	24.3%	26.4%	26.8%	26.8%
1987-1989	A	11.8%	17.3%	22.6%	17.9%	17.9%	16.5%	17.0%	17.0%
1988-1990	A	2.0%	4.7%	10.0%	2.1%	2.1%	3.5%	3.9%	3.9%
1989-1991	A	A	A	A	A	A	A	A	A
1990-1992	A	A	A	A	A	A	A	A	A
1991-1993	0.6%	A	A	A	A	A	A	A	A
1992-1994	0.6%	A	A	A	A	A	A	A	A
Avg of 3-Yr Pds	0.6%	6.6%	8.0%	10.8%	7.7%	7.7%	8.1%	8.2%	8.2%
10-Year Avg	0.0%	3.1%	3.9%	6.5%	3.3%	3.3%	3.9%	4.1%	4.1%

Table 3.5. The CFD based assessment of spring chlorophyll water quality criteria attainment in the James Lower Tidal Fresh (JMSTF1) A = attainment; % = percent of time/space not in attainment.

James Lower Tidal Fresh - Spring				SCENARIOS					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier 3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY 1*	*VATS JY 2*
1985-1987	--	--	--	--	--	--	--	--	--
1986-1988	38.2%	27.9%	7.4%	8.9%	A	A	A	6.8%	6.8%
1987-1989	41.5%	31.1%	7.4%	8.9%	A	A	A	6.8%	6.8%
1988-1990	53.3%	33.9%	7.4%	8.9%	A	A	A	6.8%	6.8%
1989-1991	41.8%	7.9%	A	A	A	A	A	A	A
1990-1992	35.9%	6.4%	A	A	A	A	A	A	A
1991-1993	24.0%	3.5%	A	A	A	A	A	A	A
1992-1994	17.3%	3.5%	A	A	A	A	A	A	A
Avg of 3-Yr Pds	36.0%	16.3%	3.2%	3.8%	0.0%	0.0%	0.0%	2.9%	2.9%
10-Year Avg	34.6%	12.9%	0.3%	0.7%	A	A	A	0.2%	0.2%

Table 3.6. The CFD based assessment of proposed summer chlorophyll water quality criteria attainment in the James Lower Tidal Fresh (JMSTF1). A = attainment; % = percent of time/space not in attainment.

James Lower Tidal Fresh - Summer				SCENARIOS					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier 3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY 1*	*VATS JY 2*
1985-1987	30.5%	11.1%	A	A	A	A	A	A	A
1986-1988	47.0%	28.9%	A	0.0%	A	A	A	A	A
1987-1989	53.4%	38.5%	A	6.1%	A	A	A	A	A
1988-1990	68.6%	52.7%	A	6.1%	A	A	A	A	A
1989-1991	56.2%	42.2%	A	1.3%	A	A	A	A	A
1990-1992	57.0%	41.7%	A	A	A	A	A	A	A
1991-1993	57.0%	43.4%	A	A	A	A	A	A	A
1992-1994	59.2%	33.9%	A	A	A	A	A	A	A
Avg of 3-Yr Pds	53.6%	36.5%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%
10-Year Avg	57.7%	36.3%	A	A	A	A	A	A	A

Table 3.7. The CFD based assessment of spring chlorophyll water quality criteria attainment in the James Oligohaline (JMSOH). A = attainment; % = percent of time/space not in attainment.

James Oligohaline - Spring				SCENARIOS					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY 1*	*VATS JY 2*
1985-1987	--	--	--	--	--	--	--	--	--
1986-1988	20.1%	A	A	A	A	A	A	A	A
1987-1989	44.2%	A	A	A	A	A	A	A	A
1988-1990	71.2%	18.3%	A	A	A	A	A	A	A
1989-1991	55.5%	18.3%	A	A	A	A	A	A	A
1990-1992	51.0%	18.3%	A	A	A	A	A	A	A
1991-1993	24.7%	A	A	A	A	A	A	A	A
1992-1994	10.5%	A	A	A	A	A	A	A	A
Avg of 3-Yr Pds	39.6%	7.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10-Year Avg	31.9%	3.6%	A	A	A	A	A	A	A

Table 3.8. The CFD based assessment of proposed summer chlorophyll water quality criteria attainment in the James Oligohaline (JMSOH). A = attainment; % = percent of time/space not in attainment.

James Oligohaline - Summer				SCENARIOS					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY 1*	*VATS JY 2*
1985-1987	A	A	A	A	A	A	A	A	A
1986-1988	4.3%	0.7%	A	A	A	A	A	A	A
1987-1989	26.4%	23.8%	18.2%	20.8%	20.1%	20.1%	20.1%	20.1%	20.1%
1988-1990	28.7%	23.8%	18.2%	20.8%	20.1%	20.1%	20.1%	20.1%	20.1%
1989-1991	38.6%	34.7%	17.8%	20.1%	20.1%	20.1%	20.1%	20.1%	20.1%
1990-1992	36.0%	30.0%	5.5%	9.3%	A	A	2.5%	3.1%	3.3%
1991-1993	44.5%	35.6%	5.5%	9.3%	A	A	2.5%	3.1%	3.3%
1992-1994	33.3%	19.6%	5.5%	9.3%	A	A	2.5%	3.1%	3.3%
Avg of 3-Yr Pds	26.5%	21.0%	8.8%	11.2%	7.5%	7.5%	8.5%	8.7%	8.8%
10-Year Avg	23.3%	16.0%	5.5%	7.7%	4.1%	4.0%	5.0%	5.2%	5.2%

Table 3.9. The CFD based assessment of spring chlorophyll water quality criteria attainment in the James Mesohaline (JMSMH). A = attainment; % = percent of time/space not in attainment.

James Mesohaline – Spring				SCENARIOS					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY1*	*VATS JY2*
1985-1987	--	--	--	--	--	--	--	--	--
1986-1988	35.7%	33.8%	11.4%	20.1%	7.1%	1.8%	13.6%	13.6%	21.1%
1987-1989	38.1%	35.1%	11.4%	20.1%	7.1%	1.8%	13.6%	13.6%	21.1%
1988-1990	55.1%	53.8%	23.9%	30.6%	18.3%	8.1%	23.1%	24.0%	26.0%
1989-1991	55.1%	53.9%	33.5%	37.3%	30.8%	12.9%	33.0%	33.8%	34.3%
1990-1992	74.2%	63.8%	37.8%	45.4%	31.6%	12.9%	36.9%	38.1%	40.1%
1991-1993	48.3%	34.3%	22.9%	29.8%	17.9%	6.4%	22.4%	23.0%	25.0%
1992-1994	16.9%	6.4%	0.1%	3.4%	A	A	A	0.1%	1.2%
Avg of 3-Yr Pds	46.2%	40.2%	20.1%	26.7%	16.1%	6.3%	20.4%	20.9%	24.1%
10-Year Avg	38.9%	33.2%	14.6%	20.9%	10.4%	2.5%	14.9%	15.4%	18.9%

Table 3.10. The CFD based assessment of proposed summer chlorophyll water quality criteria attainment in the James Mesohaline (JMSMH). A = attainment; % = percent of time/space not in attainment.

James Mesohaline - Summer				SCENARIOS					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY1*	*VATS JY2*
1985-1987	A	A	A	A	A	A	A	A	A
1986-1988	A	A	A	A	A	A	A	A	A
1987-1989	A	A	A	A	A	A	A	A	A
1988-1990	A	A	A	A	A	A	A	A	A
1989-1991	A	A	A	A	A	A	A	A	A
1990-1992	A	A	A	A	A	A	A	A	A
1991-1993	10.0%	7.0%	3.7%	4.4%	1.8%	0.6%	2.5%	2.6%	2.7%
1992-1994	9.3%	7.0%	3.7%	4.4%	1.8%	0.6%	2.5%	2.6%	2.7%
Avg of 3-Yr Pds	2.4%	1.7%	0.9%	1.1%	0.4%	0.2%	0.6%	0.7%	0.7%
10-Year Avg	0.2%	0.1%	A	A	A	A	A	A	A

Table 3.11. The CFD based assessment of spring chlorophyll water quality criteria attainment in the James Polyhaline (JMSPH). A = attainment; % = percent of time/space not in attainment.

James Polyhaline - Spring				SCENARIOS					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY1*	*VATS JY2*
1985-1987	77.5%	68.4%	20.1%	20.1%	20.1%	20.1%	20.1%	20.1%	20.1%
1986-1988	77.5%	65.4%	20.1%	20.1%	20.1%	20.1%	20.1%	20.1%	20.1%
1987-1989	52.6%	49.6%	20.1%	20.1%	20.1%	20.1%	20.1%	20.1%	20.1%
1988-1990	52.6%	36.2%	A	A	A	A	A	A	A
1989-1991	52.6%	29.8%	3.5%	6.1%	A	A	2.1%	2.8%	5.0%
1990-1992	77.5%	33.1%	3.5%	6.1%	A	A	2.1%	2.8%	5.0%
1991-1993	77.5%	36.8%	6.7%	17.9%	A	A	2.1%	3.4%	12.7%
1992-1994	59.7%	16.3%	A	4.6%	A	A	A	A	1.7%
Avg of 3-Yr Pds	66.0%	41.9%	9.3%	11.9%	7.5%	7.5%	8.3%	8.7%	10.6%
10-Year Avg	72.1%	45.4%	5.7%	9.1%	4.8%	3.5%	4.8%	5.1%	7.5%

Table 3.12. The CFD based assessment of proposed summer chlorophyll water quality criteria attainment in the James Polyhaline (JMSPH). A = attainment; % = percent of time/space not in attainment.

James Polyhaline - Summer				SCENARIOS					
Years of 3-Yr Running Avg	*'85 Ref.*	*'02 Progr.*	*Tier3*	*Opt. 4*	*VATS*	*VATS Altern.*	*VATS JR Altern.*	*VATS JY1*	*VATS JY2*
1985-1987	0.4%	A	A	A	A	A	A	A	A
1986-1988	0.4%	A	A	A	A	A	A	A	A
1987-1989	11.1%	3.5%	A	0.4%	A	A	A	A	A
1988-1990	8.0%	3.5%	A	0.4%	A	A	A	A	A
1989-1991	8.0%	3.5%	A	0.4%	A	A	A	A	A
1990-1992	A	A	A	A	A	A	A	A	A
1991-1993	A	A	A	A	A	A	A	A	A
1992-1994	A	A	A	A	A	A	A	A	A
Avg of 3-Yr Pds	3.5%	1.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
10-Year Avg	0.0%	A	A	A	A	A	A	A	A

Table 3.1. Average spring and summer chlorophyll *a* concentrations(µg/L) by model scenario for major Chesapeake Bay segments.

Major CB Segment	1985 Reference Scenario Spring	Summer	2002 Assess Scenario Spring	Summer	Tier 3 Scenario Spring	Summer	Option 4 Scenario Spring	Summer	VATS Scenario Spring	Summer	VATS Alt. Scenario Spring	Summer	VATS JR Alt. Scenario Spring	Summer	VATSJY1 Scenario Spring	Summer	VATSJY2 Scenario Spring	Scenario Summer
CB1TF	8.28	10.11	7.86	9.06	5.96	6.36	5.85	5.97	6.21	6.24	6.18	6.21	6.21	6.24	6.21	6.24	6.21	6.24
CB2OH	8.18	8.10	7.22	7.32	5.69	5.80	5.40	5.31	5.76	5.68	5.71	5.65	5.76	5.69	5.76	5.69	5.76	5.69
CB3MH	10.66	14.15	9.20	10.96	7.16	7.88	6.76	7.19	7.18	7.30	7.07	7.21	7.19	7.31	7.19	7.32	7.19	7.31
CB4MH	10.01	14.30	7.95	10.26	6.60	7.27	6.10	6.63	6.41	6.66	6.31	6.58	6.42	6.67	6.43	6.68	6.42	6.67
CB5MH	13.59	9.55	10.43	7.56	8.77	5.71	7.94	5.47	8.18	5.12	8.13	5.11	8.21	5.14	8.22	5.15	8.21	5.14
CB6PH	11.20	8.47	8.49	6.85	6.23	5.31	6.20	5.25	5.30	4.72	5.36	4.73	5.31	4.74	5.32	4.76	5.31	4.74
CB7PH	10.51	7.29	8.53	6.06	6.67	4.95	6.44	4.77	5.76	4.52	5.78	4.50	5.76	4.53	5.77	4.54	5.76	4.53
CB8PH	9.25	6.63	7.81	5.66	5.91	4.60	6.10	4.72	5.52	4.33	5.50	4.32	5.57	4.38	5.70	4.48	5.57	4.38
PAXTF	9.82	27.84	10.59	30.28	9.78	30.43	10.16	32.48	10.64	29.91	10.48	29.42	10.64	29.91	10.64	29.91	10.64	29.91
PAXOH	10.44	19.99	12.28	20.83	12.44	20.50	13.55	22.11	12.45	20.36	12.39	20.24	12.45	20.36	12.45	20.36	12.45	20.36
PAXMH	16.15	17.44	12.48	14.57	9.56	11.94	8.60	10.91	8.65	11.09	8.57	10.92	8.65	11.10	8.65	11.11	8.65	11.10
POTTF	5.97	23.53	5.30	17.47	4.88	12.50	4.56	8.57	4.92	8.47	4.78	11.90	4.92	8.49	4.92	8.49	4.92	8.49
POTOH	6.00	10.11	5.05	7.32	4.93	6.05	4.59	4.79	4.83	5.07	4.93	6.18	4.86	5.10	4.86	5.10	4.86	5.10
POTMH	16.44	12.33	14.40	10.04	10.42	7.30	10.07	6.89	9.22	6.48	9.28	6.53	9.24	6.49	9.24	6.50	9.24	6.49
RPPTF	6.07	26.33	6.77	19.76	6.96	12.14	7.01	10.84	7.23	10.62	7.22	11.22	7.23	10.67	7.23	10.67	7.23	10.67
RPPOH	6.82	12.10	7.31	10.64	7.59	8.95	7.51	8.40	7.75	8.03	7.80	8.29	7.76	8.07	7.76	8.07	7.76	8.07
RPPMH	13.48	9.67	9.79	7.90	7.28	6.51	6.95	6.25	6.24	5.77	6.37	5.86	6.25	5.79	6.26	5.79	6.25	5.79
MPNTF	2.78	5.89	2.51	4.61	2.30	4.26	2.19	3.54	2.27	4.00	2.35	4.34	2.27	4.01	2.29	4.05	2.27	4.01
MPNOH	3.65	11.45	3.67	9.99	3.97	8.47	3.78	8.22	3.95	7.85	3.96	8.26	3.95	7.91	3.95	8.01	3.95	7.91
PMKTF	2.77	7.29	2.81	7.81	3.06	7.36	3.14	7.67	2.93	7.48	2.96	7.47	2.93	7.50	3.15	7.73	2.93	7.50
PMKOH	4.91	11.21	4.90	11.08	4.66	10.38	4.83	10.30	4.67	10.13	4.68	10.38	4.68	10.18	4.79	10.57	4.68	10.18
YRKMH	15.13	12.06	11.61	10.92	9.76	9.98	9.58	9.63	9.12	9.35	9.44	9.73	9.13	9.39	9.25	9.52	9.13	9.39
YRKPH	11.82	7.99	8.47	6.85	6.39	6.03	6.21	5.89	5.66	5.57	5.88	5.69	5.68	5.59	5.77	5.63	5.68	5.59
PIAMH	12.10	10.51	7.53	7.11	5.44	5.26	5.36	5.26	4.82	4.72	4.89	4.72	4.81	4.76	4.82	4.77	4.81	4.76
MOBPH	8.90	9.08	6.71	7.44	5.11	5.94	4.83	5.73	4.41	5.32	4.57	5.48	4.42	5.34	4.46	5.44	4.42	5.34
JMSTF2	**6.82**	**8.86**	**5.93**	**9.03**	**5.00**	**9.14**	**5.80**	**10.00**	**5.32**	**9.51**	**5.33**	**9.51**	**5.01**	**9.32**	**5.08**	**9.37**	**5.01**	**9.32**
JMSTF1	**16.37**	**34.66**	**11.89**	**24.49**	**9.04**	**14.74**	**10.02**	**16.74**	**8.50**	**12.97**	**8.51**	**13.01**	**8.92**	**14.65**	**9.28**	**15.24**	**8.92**	**14.65**
JMSOH	**13.74**	**13.85**	**10.39**	**12.68**	**7.50**	**10.42**	**8.17**	**11.10**	**6.88**	**9.32**	**6.81**	**9.27**	**7.25**	**9.79**	**7.35**	**9.97**	**7.25**	**9.79**
JMSMH	**13.00**	**5.59**	**10.14**	**5.32**	**7.28**	**4.94**	**7.87**	**4.92**	**7.00**	**4.62**	**6.71**	**4.55**	**7.29**	**4.69**	**7.68**	**4.76**	**7.29**	**4.69**
JMSPH	**14.26**	**6.62**	**10.79**	**5.90**	**7.54**	**4.99**	**8.13**	**5.12**	**7.34**	**4.73**	**6.88**	**4.57**	**7.58**	**4.80**	**8.22**	**4.98**	**7.58**	**4.80**
CHOOH	10.55	21.94	10.29	20.41	9.63	18.32	9.75	18.29	9.06	17.74	9.00	17.57	9.06	17.74	9.06	17.74	9.06	17.74
CHOMH2	9.36	13.18	7.42	9.97	6.25	7.32	5.80	6.84	5.87	6.61	5.81	6.44	5.87	6.61	5.88	6.62	5.87	6.61
CHOMH1	7.91	9.84	6.38	7.45	5.24	5.70	4.83	5.28	4.77	5.23	4.72	5.16	4.78	5.24	4.78	5.24	4.78	5.24
EASMH	8.05	15.30	5.86	10.03	4.79	6.83	4.24	5.80	4.57	6.29	4.54	6.25	4.58	6.30	4.58	6.32	4.58	6.30
TANMH	12.46	9.37	10.16	7.82	8.14	6.71	7.14	5.96	7.41	6.34	7.40	6.33	7.42	6.35	7.43	6.36	7.42	6.35
POCMH	11.49	12.49	8.54	9.06	6.24	7.63	4.82	5.06	5.64	6.98	5.64	6.94	5.64	6.98	5.65	6.99	5.64	6.98

Table 6.1a. Estimated average chlorophyll *a* (µg/L) concentrations by season and James River segment based on ten year model simulations for each nutrient reduction scenario and the percent change from the 1985 Reference Scenarios. Refer to Chapters 2 and 3 of this report for scenario description and load reductions.

Segment	'85 Ref	'02 Assess	%	Tier 3	%	Opt' 4	%	VATS	%	VATS JR	%	JY1	%
Spring													
JMSTF2	6.82	5.93	13%	5.00	27%	5.80	15%	5.32	22%	5.01	27%	5.08	26%
JMSTF1	16.37	11.89	27%	9.04	45%	10.02	39%	8.50	48%	8.92	46%	9.28	43%
JMSOH	13.74	10.39	24%	7.50	45%	8.17	40%	6.88	50%	7.25	47%	7.34	47%
JMSMH	13.00	10.14	22%	7.28	44%	7.87	39%	7.00	46%	7.29	44%	7.37	43%
JMSPH	14.26	10.79	24%	7.54	47%	8.13	43%	7.34	49%	7.58	47%	7.64	46%
Summer													
JMSTF2	8.86	9.03	-2%	9.14	-3%	10.00	-13%	9.51	-7%	9.32	-5%	9.37	-6%
JMSTF1	34.66	24.49	29%	14.74	57%	16.74	52%	12.97	63%	14.65	58%	15.24	56%
JMSOH	13.85	12.68	8%	10.42	25%	11.10	20%	9.32	33%	9.79	29%	9.94	28%
JMSMH	5.59	5.32	5%	4.94	12%	4.92	12%	4.62	17%	4.69	16%	4.70	16%
JMSPH	6.62	5.90	11%	4.99	25%	5.12	23%	4.73	28%	4.80	27%	4.82	27%

Table 6.1b. Estimated average chlorophyll *a* (µg/L) concentrations by season and James River segment based on ten year model simulations for each scoping scenario and the percent change from the 1985 Reference Scenarios. Refer to Chapters 2 and 3 of this report for scenario description and load reductions.

Segment	'85 Ref	JY2	%	Scoping A	%	Scoping B	%	Scoping C	%	Scoping D	%
Spring											
JMSTF2	6.82	5.08	26%	5.19	24%	6.10	11%	6.26	8%	4.80	30%
JMSTF1	16.37	9.28	43%	10.19	38%	10.15	38%	10.45	36%	8.38	49%
JMSOH	13.74	7.35	47%	8.57	38%	8.40	39%	8.41	39%	6.88	50%
JMSMH	13	7.68	41%	8.77	33%	8.29	36%	8.64	34%	6.68	49%
JMSPH	14.26	8.22	42%	9.62	33%	8.56	40%	9.33	35%	6.87	52%
Summer											
JMSTF2	8.86	9.37	-6%	9.49	-7%	9.49	-7%	9.82	-11%	9.15	-3%
JMSTF1	34.66	15.24	56%	20.19	42%	17.67	49%	20.32	41%	12.08	65%
JMSOH	13.85	9.97	28%	11.57	16%	11.17	19%	11.55	17%	9.35	33%
JMSMH	5.59	4.76	15%	4.95	11%	4.90	12%	4.95	12%	4.57	18%
JMSPH	6.62	4.96	25%	5.34	19%	5.17	22%	5.33	20%	4.60	31%

Appendix B.

Estimated average chlorophyll *a* (μg/L) concentrations by season and James River segment based on three year model simulations for each scenario compared to the ten year calculated average presented in Tables 6.1a and 6.1b.

James Upper Tidal Fresh - Spring

Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	7.68	5.99	4.55	5.21	4.63	4.64	4.30	4.36	4.36	4.37	5.73	5.91	4.28
1986-1988	7.24	6.22	4.88	5.89	4.72	4.72	4.49	4.53	4.53	4.63	5.78	5.71	4.59
1987-1989	5.97	5.49	4.58	5.69	4.33	4.33	4.21	4.23	4.23	4.43	5.06	4.97	4.34
1988-1990	4.45	4.39	3.82	4.87	3.53	3.53	3.48	3.49	3.49	3.74	4.02	3.86	3.63
1989-1991	4.29	4.05	3.77	4.70	3.74	3.74	3.65	3.67	3.67	3.92	3.96	4.05	3.69
1990-1992	3.79	3.53	3.28	4.10	3.28	3.28	3.19	3.21	3.21	3.41	3.48	3.55	3.22
1991-1993	3.18	3.01	2.81	3.51	2.85	2.85	2.77	2.79	2.79	2.97	2.98	3.06	2.78
1992-1994	8.82	7.41	6.24	6.67	7.43	7.44	6.82	6.96	6.96	6.93	8.44	8.95	6.04
Avg of 3-yr Pds	5.68	5.01	4.24	5.08	4.31	4.32	4.11	4.16	4.16	4.30	4.93	5.01	4.07
10-yr Avg	6.82	5.93	5.00	5.80	5.32	5.33	5.01	5.08	5.08	5.19	6.10	6.26	4.80

James Upper Tidal Fresh - Summer

Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	11.51	13.38	13.15	13.96	13.99	13.99	13.63	13.70	13.70	13.28	14.03	14.52	13.50
1986-1988	11.63	13.44	13.44	14.36	13.84	13.84	13.62	13.70	13.70	13.29	13.85	14.21	13.39
1987-1989	8.48	9.99	10.45	11.13	10.94	10.94	10.59	10.65	10.65	10.19	10.72	10.80	10.65
1988-1990	8.35	8.99	9.72	10.76	9.80	9.80	9.86	9.92	9.92	9.49	9.78	9.85	9.54
1989-1991	5.89	5.93	6.29	7.28	6.67	6.67	6.75	6.79	6.79	6.41	6.57	6.65	6.47
1990-1992	7.46	7.32	8.11	8.99	8.74	8.74	8.62	8.65	8.65	8.25	8.37	8.48	8.40
1991-1993	8.10	7.73	7.65	8.38	7.99	7.99	7.71	7.75	7.75	8.08	7.70	7.88	7.67
1992-1994	9.20	8.22	8.36	8.93	8.70	8.70	8.30	8.35	8.35	9.01	8.58	9.03	8.34
Avg of 3-yr Pds	8.83	9.37	9.65	10.47	10.08	10.08	9.89	9.94	9.94	9.75	9.95	10.18	9.75
10-yr Avg	8.86	9.03	9.14	10.00	9.51	9.51	9.32	9.37	9.37	9.49	9.49	9.82	9.15

James Lower Tidal Fresh - Spring													
Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	14.54	10.42	8.01	8.84	7.57	7.58	7.74	8.25	8.25	8.88	8.93	9.32	7.40
1986-1988	21.16	13.84	10.15	10.79	9.29	9.30	9.49	10.21	10.21	11.39	11.49	11.92	9.22
1987-1989	20.39	14.79	11.33	12.27	10.46	10.47	10.79	11.33	11.33	12.70	12.86	13.18	10.54
1988-1990	22.26	15.88	11.86	12.82	10.86	10.87	11.29	11.83	11.83	13.42	13.41	13.72	10.90
1989-1991	16.08	12.64	9.87	11.23	9.42	9.43	10.07	10.20	10.20	11.29	11.05	11.32	9.31
1990-1992	15.93	12.11	9.21	10.43	8.80	8.81	9.42	9.64	9.64	10.38	10.29	10.50	8.56
1991-1993	12.38	9.21	7.19	8.25	7.09	7.10	7.69	7.78	7.78	8.14	8.00	8.19	6.82
1992-1994	11.88	9.28	7.16	8.11	6.86	6.86	7.27	7.50	7.50	7.97	8.01	8.19	6.66
Avg of 3-yr Pds	16.83	12.27	9.35	10.34	8.79	8.80	9.22	9.59	9.59	10.52	10.51	10.79	8.68
10-yr Avg	16.37	11.89	9.04	10.02	8.50	8.51	8.92	9.28	9.28	10.19	10.15	10.45	8.38

James Lower Tidal Fresh - Summer													
Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	27.54	18.66	11.89	12.87	10.31	10.34	11.70	12.15	12.15	14.90	12.97	14.88	9.23
1986-1988	36.43	24.87	14.31	15.98	12.35	12.39	14.09	14.75	14.75	19.15	16.77	19.54	11.27
1987-1989	37.08	27.44	17.12	19.27	15.17	15.22	16.95	17.65	17.65	23.00	20.73	23.26	14.47
1988-1990	39.92	30.35	18.29	21.14	16.29	16.35	18.23	18.99	18.99	25.52	22.94	25.92	15.68
1989-1991	31.20	26.68	17.53	20.31	15.84	15.88	17.43	18.02	18.02	23.81	21.49	23.78	15.37
1990-1992	32.26	25.67	15.54	18.46	13.82	13.86	15.44	16.07	16.08	22.25	19.38	22.25	13.11
1991-1993	37.58	26.33	15.22	17.88	13.27	13.31	15.09	15.76	15.76	22.05	18.70	22.04	12.33
1992-1994	40.16	23.79	13.03	14.95	11.16	11.20	12.96	13.57	13.57	19.21	16.06	19.23	10.15
Avg of 3-yr Pds	35.27	25.47	15.37	17.61	13.53	13.57	15.24	15.87	15.87	21.24	18.63	21.36	12.70
10-yr Avg	34.66	24.49	14.74	16.74	12.97	13.01	14.65	15.24	15.24	20.19	17.67	20.32	12.08

James Oligohaline – Spring Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	8.99	7.58	6.63	6.77	6.01	6.00	6.09	6.26	6.27	6.66	6.65	6.74	5.99
1986-1988	12.71	9.56	7.73	8.11	6.96	6.91	7.26	7.41	7.43	8.13	8.07	8.20	6.94
1987-1989	15.48	11.63	8.97	9.63	8.15	8.09	8.54	8.70	8.72	9.91	9.80	9.90	8.23
1988-1990	21.87	16.03	10.21	11.40	9.26	9.13	10.02	10.11	10.13	12.41	12.16	12.02	9.28
1989-1991	20.04	15.28	9.79	10.97	8.93	8.81	9.54	9.64	9.64	12.04	11.72	11.58	8.98
1990-1992	19.95	14.79	9.11	10.27	8.31	8.19	9.00	9.06	9.07	11.27	10.95	10.79	8.28
1991-1993	11.32	8.62	6.60	7.22	6.16	6.12	6.44	6.48	6.48	7.47	7.24	7.34	6.17
1992-1994	8.46	6.33	4.98	5.44	4.74	4.72	4.95	4.96	4.96	5.53	5.40	5.44	4.73
Avg of 3-yr Pds	14.85	11.23	8.00	8.73	7.31	7.25	7.73	7.83	7.84	9.18	9.00	9.00	7.32
10-yr Avg	13.74	10.39	7.50	8.17	6.88	6.81	7.25	7.34	7.35	8.57	8.40	8.41	6.88

James Oligohaline – Summer Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	10.45	8.92	7.22	7.45	6.35	6.30	6.66	6.76	6.78	7.63	7.39	7.66	6.26
1986-1988	11.78	10.16	8.03	8.35	6.99	6.93	7.37	7.47	7.50	8.57	8.31	8.60	6.93
1987-1989	14.85	13.90	12.21	12.80	11.40	11.37	11.87	12.00	12.02	13.26	13.00	13.26	11.51
1988-1990	15.41	14.54	12.85	13.54	12.08	12.05	12.54	12.68	12.70	14.07	13.79	14.04	12.25
1989-1991	15.72	15.05	13.22	14.04	12.35	12.33	12.83	12.99	13.01	14.68	14.28	14.63	12.52
1990-1992	15.33	14.55	11.36	12.45	9.68	9.61	10.29	10.50	10.56	13.20	12.50	13.09	9.74
1991-1993	16.72	15.77	12.04	13.25	10.17	10.07	10.86	11.10	11.16	14.07	13.29	13.97	10.18
1992-1994	15.57	14.15	10.95	11.96	9.33	9.25	9.94	10.15	10.21	12.66	12.01	12.58	9.33
Avg of 3-yr Pds	14.48	13.38	10.99	11.73	9.79	9.74	10.29	10.46	10.49	12.27	11.82	12.23	9.84
10-yr Avg	13.85	12.68	10.42	11.10	9.32	9.27	9.79	9.94	9.97	11.57	11.17	11.55	9.35

James Mesohaline – Spring Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	8.81	7.39	6.40	6.57	6.32	6.06	6.38	6.38	6.70	7.00	6.56	6.89	5.95
1986-1988	11.71	9.59	7.60	7.98	7.36	7.07	7.53	7.57	7.94	8.72	8.14	8.53	7.04
1987-1989	12.51	10.19	7.98	8.44	7.86	7.55	8.12	8.17	8.57	9.16	8.63	9.06	7.44
1988-1990	16.33	12.79	8.65	9.37	8.30	7.94	8.69	8.82	9.21	10.85	10.20	10.63	7.92
1989-1991	17.96	13.98	9.11	10.12	8.71	8.32	9.24	9.39	9.74	11.58	11.05	11.43	8.33
1990-1992	20.78	15.42	9.55	10.80	8.92	8.52	9.52	9.68	10.03	12.61	11.93	12.32	8.69
1991-1993	14.98	11.36	7.84	8.74	7.40	7.10	7.84	7.93	8.22	9.66	9.20	9.55	7.18
1992-1994	9.32	6.86	5.13	5.50	4.92	4.73	5.11	5.16	5.36	6.02	5.68	5.97	4.68
Avg of 3-yr Pds	14.05	10.95	7.78	8.44	7.47	7.16	7.80	7.89	8.22	9.45	8.92	9.30	7.15
10-yr Avg	13.00	10.14	7.28	7.87	7.00	6.71	7.29	7.37	7.68	8.77	8.29	8.64	6.68

James Mesohaline – Summer Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	4.02	4.07	4.08	3.94	3.78	3.72	3.82	3.82	3.86	3.87	3.88	3.88	3.73
1986-1988	4.35	4.27	4.14	4.03	3.84	3.77	3.88	3.89	3.95	4.02	4.00	4.03	3.79
1987-1989	4.85	4.78	4.66	4.59	4.41	4.36	4.45	4.46	4.50	4.57	4.56	4.58	4.38
1988-1990	5.29	5.09	4.84	4.81	4.62	4.57	4.65	4.66	4.71	4.86	4.81	4.85	4.59
1989-1991	5.35	5.19	4.99	4.95	4.76	4.72	4.79	4.80	4.84	4.97	4.93	4.95	4.74
1990-1992	6.10	5.65	5.04	5.08	4.72	4.64	4.79	4.81	4.89	5.18	5.10	5.16	4.67
1991-1993	7.67	7.04	6.14	6.25	5.67	5.53	5.81	5.84	5.94	6.38	6.28	6.38	5.57
1992-1994	7.04	6.49	5.78	5.85	5.39	5.29	5.49	5.52	5.59	5.92	5.86	5.92	5.31
Avg of 3-yr Pds	5.58	5.32	4.96	4.94	4.65	4.58	4.71	4.73	4.78	4.97	4.93	4.97	4.60
10-yr Avg	5.59	5.32	4.94	4.92	4.62	4.55	4.69	4.70	4.76	4.95	4.90	4.95	4.57

James Polyhaline - Spring Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	17.35	13.36	9.16	10.00	8.79	8.22	9.14	9.21	9.91	11.92	10.62	11.53	8.38
1986-1988	17.21	12.88	9.08	9.81	8.74	8.20	9.03	9.09	9.78	11.66	10.28	11.23	8.30
1987-1989	15.57	11.45	8.12	8.78	7.89	7.40	8.15	8.20	8.81	10.48	9.17	10.04	7.42
1988-1990	12.59	9.43	6.56	7.00	6.54	6.07	6.73	6.78	7.36	8.54	7.43	8.17	5.94
1989-1991	13.41	10.15	6.94	7.47	6.83	6.39	7.04	7.10	7.62	8.85	7.93	8.55	6.29
1990-1992	14.45	10.73	7.32	7.90	7.12	6.66	7.34	7.41	7.97	9.52	8.50	9.15	6.66
1991-1993	14.42	10.97	7.90	8.48	7.61	7.20	7.80	7.86	8.43	9.78	8.82	9.55	7.20
1992-1994	11.90	8.95	6.48	6.94	6.34	5.99	6.52	6.57	7.07	8.01	7.17	7.88	5.90
Avg of 3-yr Pds	14.61	10.99	7.70	8.30	7.48	7.02	7.72	7.78	8.37	9.84	8.74	9.51	7.01
10-yr Avg	14.26	10.79	7.54	8.13	7.34	6.88	7.58	7.64	8.22	9.62	8.56	9.33	6.87

James Polyhaline - Summer Years of 3-yr running avg	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
1985-1987	6.61	5.69	4.64	4.76	4.38	4.18	4.47	4.49	4.70	5.11	4.87	5.10	4.20
1986-1988	6.33	5.43	4.46	4.58	4.27	4.08	4.34	4.36	4.55	4.93	4.70	4.91	4.10
1987-1989	7.17	6.31	5.23	5.42	4.89	4.73	4.98	5.01	5.18	5.65	5.47	5.62	4.78
1988-1990	7.19	6.39	5.27	5.49	4.95	4.77	5.03	5.05	5.23	5.71	5.53	5.67	4.83
1989-1991	7.34	6.53	5.43	5.64	5.10	4.92	5.18	5.20	5.38	5.86	5.68	5.83	4.98
1990-1992	6.80	6.05	5.09	5.27	4.86	4.67	4.93	4.94	5.12	5.51	5.33	5.49	4.70
1991-1993	6.65	6.05	5.27	5.39	5.06	4.90	5.12	5.13	5.29	5.58	5.43	5.57	4.92
1992-1994	6.10	5.67	5.12	5.17	4.91	4.80	4.95	4.96	5.07	5.25	5.17	5.25	4.81
Avg of 3-yr Pds	6.77	6.02	5.06	5.22	4.80	4.63	4.88	4.89	5.06	5.45	5.27	5.43	4.67
10-yr Avg	6.62	5.90	4.99	5.12	4.73	4.57	4.80	4.82	4.98	5.34	5.17	5.33	4.60

Table C.1. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Upper Tidal Fresh – Spring for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Upper Tidal Fresh - Spring Chlorophyll Conc. (µg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	44.0%	42.3%	28.4%	33.5%	29.2%	29.4%	24.3%	25.4%	25.4%	28.8%	39.0%	41.1%	25.2%
06	33.5%	23.2%	4.5%	27.9%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	23.0%	13.9%	4.5%
07	14.0%	11.2%	4.4%	13.0%	4.4%	4.4%	4.4%	4.4%	4.4%	4.3%	4.4%	4.5%	4.4%
08	12.5%	4.1%	4.3%	4.5%	4.3%	4.3%	4.3%	4.2%	4.2%	4.1%	4.2%	4.1%	4.3%
09	4.0%	4.0%	4.1%	4.4%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%
10	3.9%	3.9%	4.0%	4.3%	4.0%	4.0%	4.0%	4.0%	4.0%	3.9%	4.0%	4.0%	4.0%
11	3.8%	3.9%	3.9%	4.2%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
12	3.8%	3.8%	3.8%	4.0%	3.9%	3.9%	3.8%	3.8%	3.8%	3.8%	3.9%	3.9%	3.8%
13	3.8%	3.8%	3.8%	3.9%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%
14	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%
15	3.7%	3.7%	3.5%	3.8%	3.8%	3.8%	3.8%	3.8%	3.8%	3.7%	3.8%	3.8%	0.4%
16	3.6%	3.6%	0.0%	A	3.8%	3.8%	3.7%	3.7%	3.7%	3.6%	3.8%	3.8%	A
17	3.5%	3.5%	A	A	3.7%	3.7%	2.2%	3.2%	3.2%	2.2%	3.7%	3.7%	A
18	3.2%	2.3%	A	A	3.6%	3.6%	0.1%	0.6%	0.6%	0.4%	3.7%	3.7%	A
19	3.0%	0.2%	A	A	1.5%	1.5%	A	A	A	A	3.6%	3.6%	A
20	2.9%	A	A	A	0.3%	0.3%	A	A	A	A	3.5%	3.5%	A
21	2.3%	A	A	A	A	A	A	A	A	A	2.3%	3.5%	A
22	1.3%	A	A	A	A	A	A	A	A	A	0.7%	2.4%	A
23	0.4%	A	A	A	A	A	A	A	A	A	A	1.1%	A
24	A	A	A	A	A	A	A	A	A	A	A	0.1%	A
25	A	A	A	A	A	A	A	A	A	A	A	A	A
30	A	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A

Table C.2. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Upper Tidal Fresh – Summer for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Upper Tidal Fresh – Summer Chlorophyll Conc. (µg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	69.0%	67.6%	65.0%	71.2%	66.2%	66.2%	65.8%	66.0%	66.0%	66.6%	65.7%	66.2%	65.0%
06	63.9%	57.7%	58.2%	61.2%	60.8%	60.8%	58.8%	59.4%	59.4%	63.8%	61.2%	64.0%	58.3%
07	60.6%	53.7%	54.3%	55.6%	55.0%	55.0%	53.9%	53.9%	53.9%	57.5%	56.3%	59.6%	54.3%
08	53.2%	48.1%	51.4%	54.2%	53.4%	53.4%	52.2%	52.3%	52.3%	53.8%	53.0%	56.0%	52.2%
09	43.1%	41.8%	44.6%	50.5%	48.3%	48.3%	44.0%	44.5%	44.5%	50.3%	48.0%	49.8%	44.2%
10	29.3%	32.7%	37.3%	42.6%	40.4%	40.4%	37.9%	38.1%	38.1%	43.3%	39.7%	42.1%	38.0%
11	19.2%	24.4%	28.2%	35.6%	32.5%	32.5%	29.4%	29.9%	29.9%	34.4%	34.5%	35.8%	27.8%
12	10.3%	19.3%	20.5%	25.7%	22.9%	22.9%	21.5%	22.1%	22.1%	24.5%	23.3%	27.5%	19.8%
13	3.6%	13.0%	11.2%	19.2%	14.5%	14.5%	14.5%	15.3%	15.3%	11.6%	16.8%	18.8%	11.0%
14	0.4%	7.0%	6.3%	11.7%	7.6%	7.6%	6.6%	6.8%	6.8%	6.0%	7.8%	10.6%	6.1%
15	0.0%	3.1%	3.9%	6.5%	3.3%	3.3%	3.9%	4.1%	4.1%	2.1%	3.7%	4.8%	1.5%
16	A	A	0.8%	3.3%	0.1%	0.1%	0.2%	0.3%	0.3%	A	A	1.4%	A
17	A	A	A	0.5%	A	A	A	A	A	A	A	0.0%	A
18	A	A	A	A	A	A	A	A	A	A	A	A	A
19	A	A	A	A	A	A	A	A	A	A	A	A	A
20	A	A	A	A	A	A	A	A	A	A	A	A	A
21	A	A	A	A	A	A	A	A	A	A	A	A	A
22	A	A	A	A	A	A	A	A	A	A	A	A	A
23	A	A	A	A	A	A	A	A	A	A	A	A	A
24	A	A	A	A	A	A	A	A	A	A	A	A	A
25	A	A	A	A	A	A	A	A	A	A	A	A	A
30	A	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A

Table C.3. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Lower Tidal Fresh – Spring for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Lower Tidal Fresh - Spring Chlorophyll Conc. (µg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	81.2%	78.0%	78.0%	78.0%	77.9%	77.9%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	77.9%
06	78.0%	78.0%	74.0%	78.0%	71.6%	71.6%	73.5%	73.8%	73.8%	77.9%	77.9%	78.0%	71.3%
07	78.0%	78.0%	69.4%	72.6%	63.5%	63.5%	65.0%	69.7%	69.7%	73.8%	72.1%	73.8%	62.5%
08	78.0%	75.8%	53.5%	68.6%	47.1%	47.3%	50.0%	53.7%	53.7%	63.5%	64.3%	70.0%	46.3%
09	78.0%	62.6%	38.9%	50.8%	33.4%	33.6%	36.8%	39.9%	39.9%	44.7%	50.1%	51.4%	28.7%
10	71.8%	50.3%	25.1%	39.4%	21.2%	21.3%	29.0%	31.7%	31.7%	39.0%	38.9%	40.3%	18.7%
11	64.1%	42.7%	17.1%	27.8%	9.2%	9.3%	16.8%	18.7%	18.7%	30.9%	29.8%	33.4%	6.8%
12	60.4%	36.4%	4.6%	18.6%	0.9%	1.0%	5.4%	8.9%	8.9%	21.8%	21.6%	24.2%	0.9%
13	54.1%	25.2%	1.1%	8.4%	0.5%	0.6%	1.2%	2.7%	2.7%	12.4%	10.8%	13.1%	0.8%
14	43.8%	19.0%	0.8%	3.1%	A	A	A	0.8%	0.8%	6.5%	3.3%	6.1%	0.1%
15	34.6%	12.9%	0.3%	0.7%	A	A	A	0.2%	0.2%	2.3%	1.0%	1.5%	A
16	28.2%	8.3%	A	A	A	A	A	A	A	0.8%	0.8%	0.9%	A
17	23.8%	4.4%	A	A	A	A	A	A	A	0.8%	0.8%	0.8%	A
18	21.0%	1.8%	A	A	A	A	A	A	A	A	0.2%	0.5%	A
19	18.4%	1.0%	A	A	A	A	A	A	A	A	A	0.1%	A
20	12.5%	0.9%	A	A	A	A	A	A	A	A	A	A	A
21	9.8%	0.8%	A	A	A	A	A	A	A	A	A	A	A
22	8.2%	0.4%	A	A	A	A	A	A	A	A	A	A	A
23	6.8%	A	A	A	A	A	A	A	A	A	A	A	A
24	6.2%	A	A	A	A	A	A	A	A	A	A	A	A
25	5.8%	A	A	A	A	A	A	A	A	A	A	A	A
30	2.2%	A	A	A	A	A	A	A	A	A	A	A	A
35	0.0%	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A

Table C.4. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Lower Tidal Fresh – Summer for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Lower Tidal Fresh – Summer Chlorophyll Conc. (µg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%
06	86.8%	86.8%	86.8%	86.8%	86.4%	86.5%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	85.2%
07	86.8%	86.8%	86.8%	86.8%	83.7%	83.7%	84.7%	84.9%	84.9%	86.8%	86.8%	86.8%	83.0%
08	86.8%	86.8%	84.3%	84.9%	77.6%	77.7%	83.5%	83.7%	83.7%	86.8%	84.8%	86.8%	73.0%
09	86.8%	86.8%	83.5%	83.7%	71.7%	71.7%	74.7%	78.5%	78.5%	84.6%	83.9%	84.8%	68.0%
10	86.8%	86.8%	70.6%	76.6%	62.2%	62.6%	67.7%	70.0%	70.0%	83.9%	77.2%	84.0%	54.0%
11	86.8%	85.9%	64.1%	68.5%	51.8%	51.9%	63.0%	64.0%	64.0%	73.4%	68.5%	75.2%	45.6%
12	86.8%	82.3%	60.4%	63.6%	42.0%	42.1%	55.5%	59.7%	59.7%	69.6%	64.7%	70.3%	32.2%
13	86.8%	80.5%	51.3%	60.4%	34.9%	35.6%	44.2%	46.5%	46.5%	65.7%	60.9%	66.3%	22.5%
14	84.5%	73.7%	40.5%	56.8%	27.4%	27.6%	40.5%	42.2%	42.2%	61.9%	59.1%	62.2%	16.8%
15	83.8%	70.5%	33.6%	45.8%	22.1%	22.3%	33.6%	39.3%	39.3%	60.5%	48.3%	60.5%	14.2%
16	83.5%	67.1%	30.1%	39.7%	13.7%	14.1%	28.1%	31.8%	31.8%	54.6%	41.6%	55.4%	11.2%
17	81.7%	64.6%	23.7%	36.3%	10.6%	10.9%	23.1%	27.3%	27.3%	49.5%	37.5%	51.1%	6.2%
18	80.0%	58.2%	14.9%	33.9%	7.5%	7.6%	18.0%	22.2%	22.2%	46.4%	35.6%	46.6%	4.1%
19	78.5%	54.4%	10.6%	27.9%	1.0%	2.2%	13.5%	15.9%	15.9%	43.6%	33.5%	43.4%	0.9%
20	76.5%	52.4%	5.8%	20.7%	0.2%	0.2%	8.4%	13.5%	13.5%	39.5%	26.6%	38.3%	A
21	71.2%	50.5%	0.2%	15.7%	A	A	1.6%	9.3%	9.3%	35.5%	24.4%	36.1%	A
22	66.5%	48.8%	A	12.5%	A	A	0.4%	1.7%	1.7%	32.4%	20.0%	34.0%	A
23	63.7%	46.5%	A	6.2%	A	A	A	0.1%	0.1%	29.5%	14.4%	30.1%	A
24	61.4%	40.6%	A	1.4%	A	A	A	A	A	24.8%	11.2%	25.2%	A
25	57.7%	36.3%	A	A	A	A	A	A	A	22.3%	4.8%	22.6%	A
30	46.3%	20.0%	A	A	A	A	A	A	A	0.9%	A	1.3%	A
35	35.6%	1.3%	A	A	A	A	A	A	A	A	A	A	A
40	19.0%	0.0%	A	A	A	A	A	A	A	A	A	A	A
45	8.2%	A	A	A	A	A	A	A	A	A	A	A	A
50	5.5%	A	A	A	A	A	A	A	A	A	A	A	A

Table C.5. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Oligohaline – Spring for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Oligohaline - Spring Chlorophyll Conc. (μg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	73.5%	70.0%	67.8%	70.6%	67.0%	67.0%	67.1%	67.1%	67.1%	70.4%	70.1%	70.4%	67.0%
06	70.7%	67.0%	61.9%	60.3%	52.6%	52.6%	53.2%	53.5%	53.5%	59.9%	56.4%	60.0%	52.8%
07	66.9%	59.2%	49.5%	50.6%	46.8%	46.5%	48.3%	48.7%	48.7%	52.0%	51.3%	52.0%	46.9%
08	62.4%	52.0%	39.8%	47.4%	26.8%	24.8%	32.2%	35.8%	35.9%	48.0%	47.8%	47.9%	27.6%
09	57.2%	48.5%	22.3%	36.2%	10.1%	9.4%	18.0%	20.2%	20.5%	38.8%	36.9%	37.8%	11.2%
10	53.8%	41.1%	9.2%	23.3%	1.7%	0.1%	4.4%	5.1%	5.2%	33.2%	26.1%	28.7%	0.7%
11	46.8%	37.9%	1.9%	5.5%	A	A	2.2%	2.2%	2.2%	14.4%	11.7%	13.4%	A
12	42.6%	27.7%	A	2.6%	A	A	A	A	A	3.2%	3.2%	2.9%	A
13	41.2%	20.4%	A	2.0%	A	A	A	A	A	2.7%	2.7%	2.3%	A
14	37.9%	5.3%	A	A	A	A	A	A	A	2.3%	2.2%	1.7%	A
15	31.9%	3.6%	A	A	A	A	A	A	A	1.9%	1.7%	A	A
16	26.0%	3.4%	A	A	A	A	A	A	A	A	A	A	A
17	21.0%	3.1%	A	A	A	A	A	A	A	A	A	A	A
18	16.0%	2.8%	A	A	A	A	A	A	A	A	A	A	A
19	11.6%	2.6%	A	A	A	A	A	A	A	A	A	A	A
20	9.5%	2.4%	A	A	A	A	A	A	A	A	A	A	A
21	5.6%	2.1%	A	A	A	A	A	A	A	A	A	A	A
22	4.0%	1.9%	A	A	A	A	A	A	A	A	A	A	A
23	3.5%	1.2%	A	A	A	A	A	A	A	A	A	A	A
24	3.1%	A	A	A	A	A	A	A	A	A	A	A	A
25	2.8%	A	A	A	A	A	A	A	A	A	A	A	A
30	1.9%	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A

Table C.6. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Oligohaline – Summer for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Oligohaline - Summer Chlorophyll Conc. (μg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%	86.8%
06	86.8%	86.8%	86.8%	86.8%	78.6%	77.6%	83.5%	86.1%	86.2%	86.8%	86.8%	86.8%	77.4%
07	85.4%	84.8%	71.3%	74.0%	56.0%	55.1%	62.5%	64.0%	64.5%	76.9%	74.2%	76.7%	54.8%
08	80.7%	75.8%	51.4%	59.0%	40.5%	39.0%	44.6%	45.4%	46.1%	62.8%	58.8%	63.0%	39.5%
09	70.0%	60.4%	38.9%	44.6%	26.5%	26.1%	34.1%	35.7%	36.0%	46.9%	44.4%	47.3%	27.6%
10	60.8%	50.2%	30.0%	36.3%	10.1%	9.9%	17.4%	20.6%	21.6%	37.1%	36.3%	37.1%	9.9%
11	55.2%	40.5%	17.5%	24.7%	8.7%	8.6%	9.5%	10.1%	10.2%	28.9%	24.7%	27.7%	8.7%
12	46.4%	30.6%	9.7%	17.3%	6.9%	6.7%	8.6%	8.8%	8.9%	21.4%	17.2%	21.0%	6.9%
13	37.4%	24.1%	8.5%	10.5%	5.4%	5.3%	6.8%	7.2%	7.4%	16.1%	10.2%	16.0%	5.5%
14	30.8%	19.0%	7.2%	8.9%	4.7%	4.6%	5.6%	5.9%	6.0%	9.6%	9.0%	9.8%	4.8%
15	23.3%	16.0%	5.5%	7.7%	4.1%	4.0%	5.0%	5.2%	5.2%	8.8%	7.8%	8.8%	4.2%
16	18.3%	10.3%	4.1%	5.6%	2.3%	2.2%	3.1%	3.4%	3.5%	6.7%	5.9%	6.6%	2.5%
17	15.5%	7.3%	3.3%	4.5%	1.9%	1.9%	2.5%	2.7%	2.8%	5.5%	4.7%	5.4%	2.0%
18	8.5%	5.4%	2.6%	3.7%	1.6%	1.6%	1.8%	2.0%	2.1%	4.5%	3.9%	4.4%	1.8%
19	6.0%	4.3%	1.8%	3.1%	1.3%	1.3%	1.4%	1.4%	1.5%	3.7%	3.2%	3.6%	1.4%
20	4.0%	3.2%	1.1%	2.3%	0.5%	0.6%	1.1%	1.1%	1.1%	3.1%	2.6%	3.0%	0.9%
21	2.7%	2.4%	0.4%	1.7%	A	A	0.6%	0.8%	0.8%	2.4%	2.0%	2.3%	0.1%
22	1.8%	1.8%	A	1.0%	A	A	A	A	A	1.9%	1.4%	1.8%	A
23	0.5%	1.4%	A	A	A	A	A	A	A	1.3%	0.9%	1.2%	A
24	A	A	A	A	A	A	A	A	A	0.9%	0.1%	0.8%	A
25	A	A	A	A	A	A	A	A	A	A	A	A	A
30	A	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A

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Table C.7. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Mesohaline – Spring for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Mesohaline - Spring Chlorophyll Conc. (µg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	77.4%	72.0%	61.5%	63.6%	60.5%	57.7%	60.6%	61.2%	63.3%	66.4%	62.9%	66.0%	52.3%
06	67.2%	56.7%	46.2%	46.6%	46.1%	43.9%	52.3%	52.5%	54.3%	54.1%	47.1%	56.3%	39.3%
07	61.5%	45.8%	35.3%	36.5%	34.6%	33.7%	35.4%	35.5%	38.0%	39.9%	36.9%	39.9%	33.6%
08	49.4%	38.5%	31.3%	33.5%	27.2%	24.5%	32.0%	32.2%	33.4%	35.6%	34.2%	35.4%	25.0%
09	44.5%	35.1%	23.2%	29.7%	19.3%	16.4%	22.7%	23.4%	27.0%	33.2%	31.7%	32.7%	17.6%
10	38.9%	33.2%	14.6%	20.9%	10.4%	2.5%	14.9%	15.4%	18.9%	31.0%	28.5%	30.2%	6.3%
11	37.3%	30.3%	6.8%	15.0%	A	A	2.4%	6.1%	10.9%	26.3%	18.4%	21.9%	A
12	35.2%	27.2%	A	9.7%	A	A	A	A	A	18.2%	13.8%	15.5%	A
13	32.6%	24.3%	A	A	A	A	A	A	A	12.8%	7.6%	11.5%	A
14	30.0%	17.4%	A	A	A	A	A	A	A	6.4%	2.9%	4.6%	A
15	27.6%	14.0%	A	A	A	A	A	A	A	1.7%	1.1%	1.3%	A
16	25.4%	10.3%	A	A	A	A	A	A	A	A	A	A	A
17	23.0%	7.4%	A	A	A	A	A	A	A	A	A	A	A
18	19.7%	3.0%	A	A	A	A	A	A	A	A	A	A	A
19	14.8%	1.3%	A	A	A	A	A	A	A	A	A	A	A
20	11.5%	A	A	A	A	A	A	A	A	A	A	A	A
21	10.0%	A	A	A	A	A	A	A	A	A	A	A	A
22	9.2%	A	A	A	A	A	A	A	A	A	A	A	A
23	6.9%	A	A	A	A	A	A	A	A	A	A	A	A
24	2.9%	A	A	A	A	A	A	A	A	A	A	A	A
25	1.3%	A	A	A	A	A	A	A	A	A	A	A	A
30	A	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A

Table C.8. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Mesohaline – Summer for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Mesohaline - Summer Chlorophyll Conc. (µg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	33.5%	26.1%	18.6%	17.1%	9.9%	9.1%	11.8%	13.2%	15.6%	18.5%	17.4%	18.2%	9.4%
06	15.6%	9.6%	2.7%	4.5%	0.6%	0.5%	0.8%	1.0%	1.1%	5.5%	4.9%	5.5%	0.5%
07	6.2%	4.0%	0.3%	0.3%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%
08	3.4%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%
09	2.4%	0.2%	0.1%	0.1%	A	A	A	A	A	0.1%	0.1%	0.1%	A
10	0.2%	0.1%	A	A	A	A	A	A	A	A	A	A	A
11	A	A	A	A	A	A	A	A	A	A	A	A	A
12	A	A	A	A	A	A	A	A	A	A	A	A	A
13	A	A	A	A	A	A	A	A	A	A	A	A	A
14	A	A	A	A	A	A	A	A	A	A	A	A	A
15	A	A	A	A	A	A	A	A	A	A	A	A	A
16	A	A	A	A	A	A	A	A	A	A	A	A	A
17	A	A	A	A	A	A	A	A	A	A	A	A	A
18	A	A	A	A	A	A	A	A	A	A	A	A	A
19	A	A	A	A	A	A	A	A	A	A	A	A	A
20	A	A	A	A	A	A	A	A	A	A	A	A	A
21	A	A	A	A	A	A	A	A	A	A	A	A	A
22	A	A	A	A	A	A	A	A	A	A	A	A	A
23	A	A	A	A	A	A	A	A	A	A	A	A	A
24	A	A	A	A	A	A	A	A	A	A	A	A	A
25	A	A	A	A	A	A	A	A	A	A	A	A	A
30	A	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A

Table C.9. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Polyhaline – Spring for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Polyhaline – Spring Chlorophyll Conc. (µg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	86.8%	86.8%	76.2%	80.6%	80.7%	70.0%	81.9%	82.3%	83.3%	84.7%	80.2%	86.1%	67.3%
06	86.8%	84.8%	64.2%	65.2%	64.2%	59.5%	64.5%	64.6%	73.2%	76.6%	69.3%	75.5%	58.7%
07	86.8%	76.0%	54.6%	59.2%	53.5%	35.8%	55.2%	55.5%	61.7%	69.3%	62.5%	67.3%	35.3%
08	83.6%	64.5%	17.0%	40.0%	15.3%	11.0%	17.1%	29.3%	50.2%	61.1%	49.6%	58.5%	11.3%
09	78.7%	60.2%	9.8%	14.2%	8.2%	6.0%	9.4%	9.9%	14.8%	46.3%	29.0%	42.6%	6.3%
10	72.1%	45.4%	5.7%	9.1%	4.0%	3.5%	4.8%	5.1%	7.5%	33.0%	11.6%	28.8%	3.5%
11	59.6%	31.8%	3.5%	5.4%	A	A	3.5%	3.5%	4.4%	11.4%	6.3%	8.8%	A
12	51.3%	16.7%	A	4.0%	A	A	A	A	0.0%	6.2%	4.8%	5.6%	A
13	43.7%	10.7%	A	A	A	A	A	A	A	4.9%	4.0%	4.8%	A
14	35.9%	6.6%	A	A	A	A	A	A	A	4.0%	A	3.9%	A
15	31.4%	5.3%	A	A	A	A	A	A	A	0.2%	A	A	A
16	16.6%	4.8%	A	A	A	A	A	A	A	A	A	A	A
17	10.8%	A	A	A	A	A	A	A	A	A	A	A	A
18	8.2%	A	A	A	A	A	A	A	A	A	A	A	A
19	6.2%	A	A	A	A	A	A	A	A	A	A	A	A
20	5.6%	A	A	A	A	A	A	A	A	A	A	A	A
21	5.3%	A	A	A	A	A	A	A	A	A	A	A	A
22	4.8%	A	A	A	A	A	A	A	A	A	A	A	A
23	4.4%	A	A	A	A	A	A	A	A	A	A	A	A
24	A	A	A	A	A	A	A	A	A	A	A	A	A
25	A	A	A	A	A	A	A	A	A	A	A	A	A
30	A	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A

Table C.10. Cumulative frequency distribution (CFD) based level of attainment (A) or non-attainment (%) in time and space assuming different chlorophyll a criteria concentrations in the James Polyhaline – Summer for all scenarios. The proposed chlorophyll a criteria for this season and river segment is highlighted.

James Polyhaline - Summer

Chlorophyll Conc. (µg/L)	1985 Reference	2002 Assess	Tier 3	Option 4	VATS	VATS Altern.	VATS JR Altern.	VATS JY1	VATS JY2	Scoping A	Scoping B	Scoping C	Scoping D
05	59.0%	51.1%	34.9%	38.9%	24.8%	19.4%	31.3%	31.5%	36.9%	43.9%	40.9%	43.9%	20.0%
06	44.0%	35.2%	6.4%	10.6%	2.4%	0.7%	3.5%	3.9%	6.4%	19.3%	12.1%	18.8%	1.2%
07	30.0%	13.2%	A	0.1%	A	A	A	A	A	1.1%	0.2%	0.6%	A
08	14.7%	0.9%	A	A	A	A	A	A	A	A	A	A	A
09	3.7%	A	A	A	A	A	A	A	A	A	A	A	A
10	0.0%	A	A	A	A	A	A	A	A	A	A	A	A
11	A	A	A	A	A	A	A	A	A	A	A	A	A
12	A	A	A	A	A	A	A	A	A	A	A	A	A
13	A	A	A	A	A	A	A	A	A	A	A	A	A
14	A	A	A	A	A	A	A	A	A	A	A	A	A
15	A	A	A	A	A	A	A	A	A	A	A	A	A
16	A	A	A	A	A	A	A	A	A	A	A	A	A
17	A	A	A	A	A	A	A	A	A	A	A	A	A
18	A	A	A	A	A	A	A	A	A	A	A	A	A
19	A	A	A	A	A	A	A	A	A	A	A	A	A
20	A	A	A	A	A	A	A	A	A	A	A	A	A
21	A	A	A	A	A	A	A	A	A	A	A	A	A
22	A	A	A	A	A	A	A	A	A	A	A	A	A
23	A	A	A	A	A	A	A	A	A	A	A	A	A
24	A	A	A	A	A	A	A	A	A	A	A	A	A
25	A	A	A	A	A	A	A	A	A	A	A	A	A
30	A	A	A	A	A	A	A	A	A	A	A	A	A
35	A	A	A	A	A	A	A	A	A	A	A	A	A
40	A	A	A	A	A	A	A	A	A	A	A	A	A
45	A	A	A	A	A	A	A	A	A	A	A	A	A
50	A	A	A	A	A	A	A	A	A	A	A	A	A